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## Reflected Ultraviolet Digital Photography with improvised UV image converter

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It is a long standing and well established belief or fact that making photographs by ultraviolet radiation with digital cameras is impossible due to the very low blue and UV sensitivity of CCD image receptors. Unlike the situation with Infrared, where the CCDs are very sensitive and manufacturers have to take pains to make sure to exclude such radiation from reaching the CCD sensor so that its visual response to red, green and blue is not contaminated by infrared, in the UV such precautions are unnecessary.

It turns out that even with the extra protection that manufacturers include in their cameras to exclude infrared from the sensors, often it is quite possible to record by infrared energy with the simple expedient of placing an infrared transmitting filter over the camera lens. Extended exposure times may be needed but if one is willing to tolerate a certain amount of digital noise quite acceptable records in the infrared may be secured with just about any standard CCD sensor equipped digital camera.

The situation in the UV, as mentioned earlier is not quite as simple. There are, of course, specialized cameras whose CCD's are manufactured in such a manner as to make it possible for them to record ultraviolet. However, as they are specialized they are also not readily available and they are expensive.

I always wondered what would happen if I simply followed the procedure used for recording infrared with a digital camera and this is to place a UV transmitting, but light, or visual, blocking filter over the camera's lens. The standard filter for doing this in the UV with standard B&W film is the Wratten 18A glass filter. This filter has very good transmission in the near UV region of the spectrum, from about 300 to 400 nanometers. Photographing through this filter using Polaroid Type 667 (3200 speed B&W film) I was able to make records of a plant by reflected UV very easily.

The interesting thing was that when I placed the 18A filter over my Nikon 990 camera's lens and used an exposure time of 8 seconds, I was also able to get an image. But it did not look quite like the image I recorded with the Polaroid film. At first I attributed the difference to the fact that the 18A filter not only transmits UV but it also has a "notch" in the far red and near infrared area. If the CCD sensor truly could not respond to UV I should not have recorded anything.

As I pondered this situation I remembered that the Nikon 990 has a very good IR blocking filter over its CCD sensor. Much better than the Nikon 950 which can be relatively easily used to make reflected IR photographs looking through a Wratten 87 or even 87C filter. So I went back and redid the test. It was a bit windy but the illustration

here shows that indeed the visible and UV record made with an 18A filter over the camera lens do exhibit characteristic differences associated with the different look of this flower by visible and UV. When I stacked a 2E filter on top of the 18A there was no response from the 990's sensor. This indicated a very low, if any at all, IR response and thus that indeed when the camera recorded through the 18A it was responding only to the UV component of the scene. The UV that passed through the 18A filter.

Well, I am adding now (Feb 2004) to this article based on the fact I just acquired a Canon Digital Rebel camera and I decided to check whether it could record wavelengths for which it was not designed, much like the Nikon 990. The situation with this camera is a bit better than with the 990 in that the Rebel has the ability to make exposures of indefinite length albeit at the expense of accumulating some noise. So, step one was to simply check response and not worry much about subject, etc. The camera indeed could record through the 18A as well as a Wratten 87. In my opinion it is always best to ignore whatever color the camera assigns to an image made by either wavelength as UV and IR do not have "color" as we know it. For this reason to make the comparison a bit easier to "see" I made the normal color record that the camera provides for a visual record a black and white reproduction as well. Both the IR and the UV records took a considerable longer exposure time in sunlight with the lens wide open than the visible record. Possibly by a magnitude of something like 1,000 or so.

Beyond the fact that the camera could photograph outside the visible spectrum given enough energy, I noticed that the IR record seemed to suffer from a "hot spot" in the center of the frame. Determining its cause is left for another time when I have some to deal with it.



OK ... the saga continues (August 2004) with an experiment related to the photography of some flowers with the Canon Digital Rebel fitted with an 18A ultraviolet transmitting filter. The results were quite interesting and to some extent "colorful" although it is recognized that color can not exist in an UV record because this region of the spectrum is not visible and thus is not "light". The fact that colors did appear in the record may be caused by the fact that the various color filters placed on the CCD of the camera had uneven response to UV rays arriving at them from the subject. In any case, the colorful UV record is shown here accompanied by the more appropriate B&W rendition of the same subject. Black Eyed Susan flowers apparently have strong absorption of ultraviolet extending a significant distance outward from the center of the flower and into the visually uniformly yellow area of the flower petals.



Also, a sunflower and a buttercup appear to exhibit similar appearance or behavior in the ultraviolet as the Black Eyed susan. The Sweet William's flower is quite striking in its behavior and although the color interpretation taken through the 18A UV filter is visually appealing it appears that the pigmentation of the flower is such that it reflects UV exactly the same from its visually white areas as from those that are red in the visible spectrum. The other "weed" flowers are also strange looking.

What this means I am not qualified to speculate but the purpose of this photographic exercise is to demonstrate that in different areas of the electromagnetic spectrum the reflectance of subjects may be quite different than in that portion of the spectrum that we can see and that we call "light".

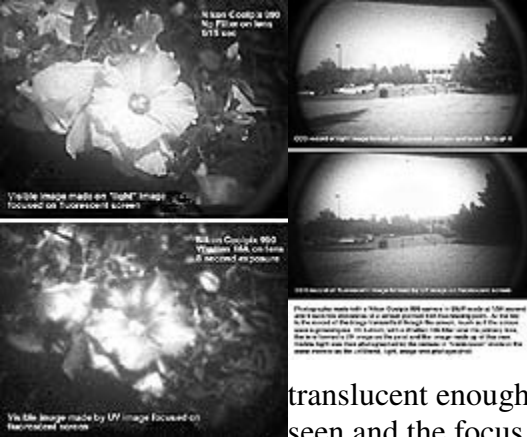


**... and now to the topic that got me started on this project in the first place!**

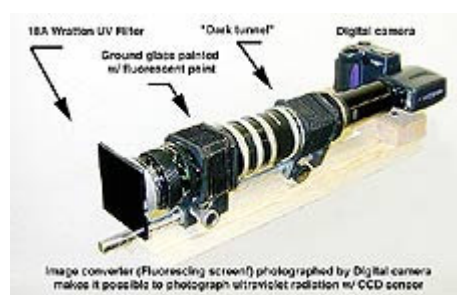
Anyway, I decided to take an alternate route to make photographs by reflected UV using a digital camera. This procedure would be based on the use of an "image converter" that would take the ultraviolet (and IR, although the IR would be of no consequence) image transmitted by the 18A filter and focused by a lens onto it and transform the UV image into one made up of, fluorescent, visible wavelengths. Then I could photograph these visible wavelengths with any camera. Including a digital, CCD equipped, camera.

Image converters are usually quite expensive devices in themselves but, in fact, almost any substance that fluoresces on exposure to ultraviolet performs the desired task and can be used as the basis for a UV-to-visible converter.

So, I took a piece of glass and spray painted it with fluorescent yellow paint. After it dried I covered it with the 18A filter material and then used a lens to form an image of a "black light" lamp through the 18A filter onto the fluorescent paint layer. Sure enough, right through the 18A filter the image of the lamp could be clearly seen. And, if it could be seen then it followed it could be photographed.



I next assembled a set of extension tubes and bellows as shown in the illustration. The fluorescent "ground glass" is placed at the rear of a bellows and the distance from the lens to it is adjusted to sharply focus and object at infinity. This can be done much the same way as if the paint were traditional ground glass. The paint is translucent enough so that the image formed on it by the camera lens can be easily seen and the focus can be properly adjusted.



Behind the fluorescent glass carrying bellows I then fitted a series of extension tubes whose function was to simply act as a dark tunnel to exclude light from the fluorescent glass. At the end of the extension tubes I then fitted the lens of the Nikon 990 camera and made sure that no light was allowed to leak into the tunnel. The length of the tunnel was such that the camera could focus on the image formed on the fluorescent screen. All the components of the system were mounted in-line and firmly attached to a bracket that then itself was equipped with a tripod socket and attached to a tripod.

Finally it was time to check out the system. At least from a preliminary point of view. The camera system was used to photograph the same flower as I had photographed with the Polaroid film and then also to photograph a parking lot that happened to be available. The difference in rendition between a visible record and a record made of the fluorescent image formed through the 18A filter onto the layer of paint is very indicative of the fact that there are differences between the two views of a given scene.

It is obvious that the Polaroid record is a lot sharper and has more detail than the record made with the CCD equipped camera off the fluorescent screen but this should not negate the fact that something deemed impossible for a digital camera to do was, in fact, accomplished. At least as a feasibility study or as a demonstration-of-concept. It would take a little time and a bit more refinement of the parts and components to possibly make this approach one that could have useful applications anytime that a reflected ultraviolet record needs to be made but when funds are limited and technical quality can be somewhat less than that which might be delivered by instruments specifically designed for the purpose. I hope you agree that this approach certainly has a lot to be said for in terms of serving as an educational tool to illustrate image making with wavelengths that are otherwise invisible to human eyes ... and also most digital cameras as well!

If you have questions or would like to discuss any aspect of this process write to me at the Rochester Institute of Technology, 70 Lomb Memorial Dr., Rochester, NY 14623 or

send me e-mail at: [andpph@rit.edu](mailto:andpph@rit.edu)